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ABSTRACT

This paper describes the evolution of a national research plan for computers and education, an approach which was initiated in the Netherlands in 1983. Two phases can be recognized in the Dutch experience: one from 1984 until 1988 and one from 1989 until 1992. Building upon the experiences of the first phase, research plans for the second phase are outlined. General conclusions are that research plans should be formulated within a concrete and well-defined framework, oriented more toward implementation issues than toward theoretical research questions and undertaken in a context of international cooperation. Priorities for the next phase of research include: (1) procedures and criteria for software evaluation by teachers; (2) alternative approaches to the inservice training of teachers in computer usage; (3) computer applications in vocational education; (4) cooperative learning and computers; (5) the effect of computers on higher cognitive skill development; (6) the applicability of artificial intelligence techniques to the production of courseware; and (7) the development of interactive coaches. (Author/GL)

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The Evaluation of a National Research Plan to Support the Implementation of Computers in Education in the Netherlands

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Abstract

This paper describes the evolution of a National Research Plan for Computers and Education in the Netherlands. This approach was initiated in 1983. There are two phases that can be recognized in the Dutch experience: one from 1984 until 1988 and one from 1989 until 1992. The paper described the research plans for the second phase, based upon the experiences of the first, and draws some general conclusions. These conclusions are:

- Research plans should be formulated within a concrete and well defined framework.
- The present orientation of research plans in this area should focus much more upon implementation issues than on theoretical research questions.
- There is a need for international cooperation in this area.

1. Background

1.1 Organisation of Educational Research in the Netherlands

Educational research in the Netherlands is executed by universities after being initiated either by them or the Institute for Educational Research (SVO). This Institute does not perform the research itself but invites universities to apply for research projects. A formal evaluation and decision procedure is followed after applications are sent in to the SVO. In order to create research frameworks for different aspects of education, SVO regularly gives assignments for the execution of so-called 'problem exploration studies'. Such studies are focussed toward a certain educational area and result in inventories of crucial research approaches and research questions.

1.2 Introduction of Computers in Dutch Education

In 1984 the Dutch government launched a five-year Informatics Stimulation Plan, the INSP. The major emphasis of the plan was to create a momentum for the introduction of computers in business, research and education. A specific part of the plan focussed on stimulation of the area of computers and education and had a budget of approximately 160 million US $. Projects were set up to support the introduction of computers in different educational sectors: primary, secondary (general and vocational), and special education. Special programs were initiated to start the development of a national and regional infrastructure and methodology for courseware development. Much emphasis was put on teacher training (inservice and preservice). A very small part (2.5%) of the plan was related to research.

The INSP ended in December 1988, and has been followed by another five-year plan: the PRINT-project. The major emphasis of this plan is to continue the efforts started during the INSP, and to specifically focus on the implementation of computers into education. The budget for this plan is even higher than the INSP-budget (250 million US $).

2. Initial Research on Education and Computers

2.1 The First Problem Exploration Study

Although research on computers in education started in the Netherlands at the end of the 1960s, the first systematic problem exploration study in this area was carried out in 1984. The report was discussed in a broader context at a working conference at the end of 1984. The intention of that conference was to formulate the foundation of a four-year plan for research to be executed during the period 1985-1988. In reality, however, much discussion carried on after the conference about the choices that had been made for specific research lines. The great variety of suggested research topics and limitations in the budget added to the general confusion. As a result a great diversity of research projects was carried out during the period 1985-1988. The lesson to be learned was that a research plan should be developed in a clearly stated and specific context, in order to avoid 'fundamental' discussions which can result in confusion and endless compromises.

2.2 Research during the Period 1985-1988

In this period 42 research projects were executed. These projects were originated from three directions: the official program line of SVO about computers and education (18), the research plan connected with the Informatics Stimulation Plan (24), and research projects suggested by individual researchers (3).

An analysis of these research efforts show little coherence among them. However three clusters of activities emerge:

- Feasibility studies, surveys and evaluation research (20 projects).
- Research and development of educational software (8).
- Theoretical research (14).

2.2.1 Feasibility Studies and Surveys

At the start of the period 1985-88 there was great need for feasibility studies and surveys, to get a better idea about the extent of initial exploratory work. A great emphasis was also placed on the preparation of the so-called 'Experimental Schools' Project. This is a project in which research groups at universities work closely with one or two secondary schools to create a kind of practical laboratory in which the implementation of computers in the current curriculum can better be studied. In the Netherlands, three of these experimental schools have been created, two in connection with the University of Twente and a third in connection with the University of Amsterdam and the University of Utrecht.

An examination of the feasibility studies and surveys suggests that:

- The introduction of the use of computers in schools takes much more time than was expected. An 'incubation' time of two years is felt to be minimum.
- One does not get the impression that surveys have a crucial influence on the formulation of governmental policy. When there is no direct connection between surveys and follow-up studies, especially policy-oriented activities, one can question the value of these surveys, especially as they loose their topicality very rapidly.
- Although there was considerable experience in higher education about how to use computers in education, the activities of the INSP were not related to the research results and experience of this sector. This lack of cooperation was caused by the fact that university education was excluded from the INSP.

2.2.2 Software Development Research

A distinction can be made between software development projects whose sole goals are to develop products to be used in classrooms and projects intended to produce products to support more theoretical research. Development research of the second type started much later than the feasibility studies and surveys in the INSP and less money was available. On the other hand, much money was spent on the first type of software development work in school projects. Unfortunately, no connection was arranged between these school-oriented 'production' projects and the more theoretical 'development/research' projects.

When the research-oriented software was compared with traditional learning situations in classrooms, its effects on learning outcomes yielded no clear results.

In general the following conclusions can be formulated about the 1985-1988 software development activity:

- The complexity of writing computer-aided learning programs beyond the drill-and-practice mode is highly underestimated.
- There was no integration of 'production' projects and 'development/research' projects. However, each should complement the other.
- There was no adequate software development infrastructure in the Netherlands; too many research institutes want to be involved in this area but they lack the hardware, the software and professional experience to work in an efficient way. Creating a limited number of high quality software development units seems to be desirable.

2.2.3 Theoretical Research

Theoretical research activities were generally originated by individual researchers. One central theme can be recognised in those projects:

The development of effective feedback procedures during the interaction of students with a computer program, including the construction of intelligent tutoring systems and computer coaches.

However, no significant progress can be reported.

Because of the complexity of this area, it is highly desirable that cooperation among researchers in the application of artificial intelligence techniques to computer-based education be organised, certainly in the Netherlands, and maybe even on an international scale.

3. Second Problem Exploration Study

As already stated in section 1.2, the INSP finished at the end of 1988 and SVO wanted to set up a new research line for education and computers for the period 1989-1992. A second problem exploration study was therefore announced in early 1988. Based upon the experiences of the first problem exploration study, the new research agenda was called to be written in a much more specific form. The letter of assignment of the second problem exploration study described this framework as follows:

> 'After considerable efforts done in this area by the government, especially in relation to hardware provisions, teacher training and courseware development, there is a general feeling that the time has come to get better and more precise insight in the effects of the invested money. Therefore, a research agenda has to be established whose results give concrete indications about the effects of computers in education, and through which it will become possible to evaluate the investments of the past'.

Given this assignment, a new assessment was made of the current situation regarding computers and education in schools and a general framework was developed into which a new research agenda could fit. This new assessment and framework are described in the following sections.

4. Current Situation in Schools -1988

As noted in section 3, preparation for the second problem exploration study on computers and education began at the end of 1987. To support this study, a survey was conducted during 1988 concerning the actual state of affairs of the use of computers in Dutch education. The major conclusions of the survey were:

- Although the average number of computers in Dutch secondary schools is 23, schools still express a need for more hardware.
- The current standard in Dutch secondary education is MS-DOS. Schools however prefer a standard that allows more possibilities.
- The current policy is concentrated on the introduction of computers at the micro level (referring to direct student interactions). More emphasis should be put on the meso- and macrolevel (relating to supporting the teacher and to school organisation) and the mutual relations between these levels.
- Interest for computer-aided learning is not the same in the different school sectors. In the vocational sector there is little interest in computer-aided learning.
- The choice of courseware by schools is not very well structured.
- Development of courseware by teachers is seen less frequently.
- Besides the need for a computer laboratory at school, there is a growing need to also have computers available outside this laboratory.
- Schools need a systems person to take care of the daily maintenance of the computer systems.
- The potential influence of computers on school organisation and school management has to be better realized.
- Inservice training of teachers should focus much more on subject-oriented training; it is necessary to develop creative solutions to solve the problem of the huge numbers of teachers to be trained.
- Teachers feel they have insufficient information dissemination about computers in education. The transfer process regarding such information needs a much more explicit approach.

Of these points, the major complaints expressed by teachers are about lack of support and lack of information dissemination and transfer. In addition they wish to be better able to evaluate courseware themselves and to get concrete suggestions about how to integrate computer usage in the curriculum.

5. A General Framework

Based on these survey results (section 4), previous research from 1985-1988, and more general experience, a conceptual framework was developed to guide the further work of the second problem exploration study. It was first decided that this conceptual framework will not be one which focuses directly on student performance. This may seem surprising, given the prime importance of learner outcomes in any consideration of the impact of computers in education. However, there are two major sets of reasons that make systematic assessment of learner outcomes, presumably as caused or mediated by a computer application within the learning experience, limited in effectiveness at this time. The remainder of this section summarizes the rationale for the conceptual framework and gives a brief description of its general components.

5.1 Reasons for Difficulty in Assessment of Impact of Computers on Learning

There are at least two sets of reasons which make direct assessment of the impact of a specific computer intervention difficult at the present time. These relate to the complexity of the computer-use environment and to measurement difficulties.

5.1.1 Complexity of Computer-Use Environment

One of these sets of reasons relates to the rapidly changing nature, and relative immaturity (with relation to the support of computer-learning experiences), of the environment surrounding computers in schools. For example, teachers vary substantially in their knowledge and expertise with regard to either computer management in itself or its pedagogical application and integration. Learning resources to be used in conjunction with new technologies also vary substantially in many ways, such as in characteristics of the user environments; these variations will have a strong effect on the subsequent deployment and impact of computer-related experiences on the learner. Characteristics of the surrounding learning environment itself, ranging from social and physical characteristics of the situation as experienced by the individual learner to the support offered his teacher from either the immediate schoool environment or provided by the larger external educational support system, also have a substantial influence on eventual learner impact.

These three major sets of influences -- teacher, materials, and surrounding organization -- are highly multifaceted and together form the boundary parameters within which all learning impact associated with computer use occurs. A major reason why so much current research activity attempting to illuminate learner outcomes as mediated by computers is inconsistent or unconvincing is that the larger network which saturates and shapes this mediation is treated as if it were a homogeneous constant. Before we can fairly comment on the impact of computers on the learner we must know more about the influence of this surrounding network, at least to the extent of being better able to systematically elaborate its most salient characteristics relative to the subsequent impact of computer experiences.

5.1.2 Limitations in Measurement Strategies

A second reason for postponing a direct focus on learner outcomes for the current phase of SVO-supported research activity is the problem of measurement. Reliable and valid assessment criteria, and instrumentation to measure the extent of change relative to those criteria, are not well established. Questions concerning the relative advantage of one approach to teacher training compared to other approaches, for example, cannot be answered in an efficient or valid way without prior agreement as to what standards are to be used for "success" and how they are to be systematically and reliably applied. Criteria relating to cost-benefit analyses are particularly useful, yet no common procedure exists to determine a basal framework for cost-benefit quantification. Without improved strategies for assessment of both process and outcomes -- not only of student performance but also of auxillary variables such as those relating to materials development, teacher support, and organizational variations -- assessment will be limited to imprecise and therefore unproductive appraisals with little generalizability. Thus the second overiding concern of the conceptual framework for the second problem exploration study is a focus on appropriate, manageable strategies for sensitive and valid measurement of variation with respect to critical points in the computer-impact system. An intention to focus directly and

immediately on learner outcome variables without the tools to sharpen or even decode what is seen through the lens of that focus may at the least be premature and at the more serious lead to faulty conclusions.

Based on this rationale (a rationale which is implicitly confirmed by the results of the field surveys in section 4). Figure 1 shows the simplified conceptual organization that was suggested for the 1989-1992 phase of computer-related research activity:

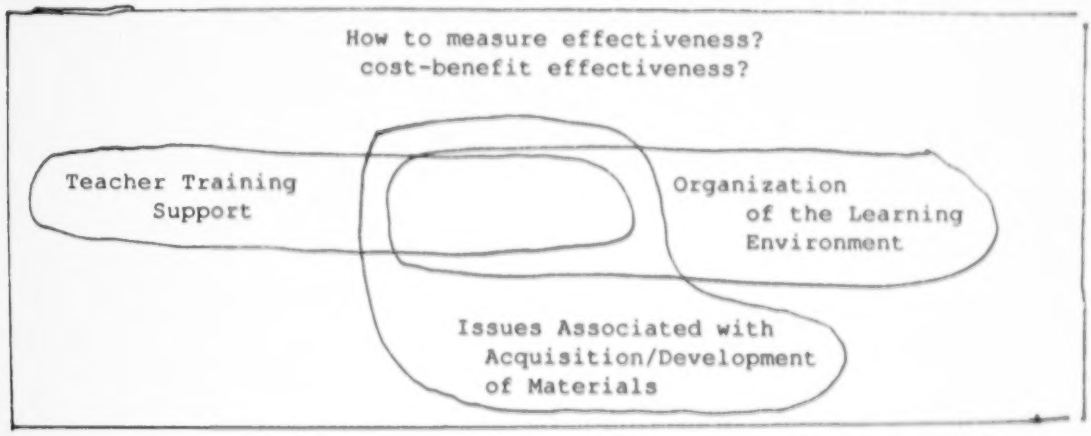

Figure 1. A general conceptual framework for research activity on the impact of computers in the school setting.

5.2 Elaborated Research Agendas: An Overview

Given this conceptual framework diagrammed in Figure 1, research agendas can be organized in a variety of ways. Based on the survey responses obtained for this study and summarized in section 4, six general areas of need emerged. These field-based needs can be summarized as: software suitability assessment, teacher training, teacher support, school and instructional organization, measurement and evaluation issues, and software development and acquisition. Each of these areas was examined in some detail and suggested research topics discussed. The following sections summarize the discussions that appeared in the second exploration study.

5.3 Software Assessment

Teachers consistently indicate that they feel they have inadequate resources for effective evaluation of software. From the teachers' perspective, their major needs are resource-related: they indicate they need more time for software evaluation, more software to evaluate, more access to hardware (both at school and at home) for software evaluation purposes, and more technical support to help them manage unfamiliar software. A related issue is who should organize and support these resources -- the school? the region? the educational support system? perhaps even the software or hardware vendors?

Research, however, indicates a more fundamental problem in connection with software assessment. This problem relates to the criteria around which such assessments are based. There is no guarantee that, given time and resources, teachers will make insightful educational appraisals of the software they are inspecting. On the contrary, various studies show that

teachers vary considerably in their perspectives with regard to software suitability, and fundamental to this variation is a lack of consensus on appropriate criteria for evaluation. These criteria can relate to both technical and pedagogical considerations but also to management and cost-effectiveness perspectives. Teachers benefit from guidance and training in the use of a variety of evaluation criteria and in instruments that encapsulate those criteria. The task is made more difficult by the need for different perspectives for different types of software -- drills, tutorials, simulations, data capturing and analysis, open-ended tool products, "real-world" products such as applications packages, and specialized software for vocational education. Strategies for priorizing evaluation criteria are also important -- what characteristics are most critial in terms of suitability appraisal? The research literature about software evaluation largely reflects work done in the early 1980s before the emergence of many of the types of open-ended or tool-type software now considered so important in educational settings. New work is necessary on efficient and effective methods for appraising the contemporary variety of educationally applicable software as well as on techniques for training teachers to apply these methods, given the typical constraints on teachers' time and on resources available for evaluation.

Other issues are also important. Who should provide the training for teachers in software evaluation? Who should train these trainers? What influence can be brought to bear on manufacturers for the provision of representative demonstration disks that can allow teachers to interact adequately with a variety of software before purchasing decisions are made? Also, what is the role of external sources of software evaluation, such as teachers' journals? How well referred to are printed reviews of software? Is there a place for the use of media for creative new approaches to software evaluations (such as providing videotapes or even interactive videodisks, available at centralized resource centres, that highlight features of a variety of software packages dealing with the same general topic)?

In summary then, the following questions need further research and offer both theoretical and practical payoff:

5.3.1 What are effective criteria for the evaluation of different types of software for use in educational settings? The criteria should consider:
- potential instructional impact relative to other methodologies
- technical features, such as user interfaces and options for teacher adaptation of program content
- cost-effectiveness and cost-benefit
- implementation considerations, such as management challenges in the classroom setting

How can these criteria be most efficiently assessed?

5.3.2 How can teachers be trained to apply these criteria? How can we measure the effectiveness of the training? Who should organize, staff, and finance the training? In what situations might it be more effective for teachers to use published evaluations of software from external sources than to perform their own evaluations?

5.3.3 In what ways can technology be used to expand the variety of methods available to teachers for software appraisal?

5.3.4 What types of local organizational support can be most helpful to teachers in facilitating their software evaluation activities? Who can most effectively take the initiative in procuring software for evaluation activities? What sorts of arrangements can be made between education authorities and software distributors to maximize teachers' opportunities for convenient access to software for evaluation? Should released time for software assessment be made available to teachers? How much time is reasonable?

Cluster 5.3.1 can be considered at the theoretical level; the other clusters relate more to applied research. The experimental schools could serve as testing sites for the organizational and developmental ideas identified in these other clusters.

5.4 Teachers and Computer-Related Training

5.4.1 Current Training Perceived as Inadequate

As was found with respect to the specific issue of software evaluation, the results of the survey in section 4 indicate that teachers more generally perceive their training with respect to computers to be inadequate and even inappropriate. Teachers both in and outside of The Netherlands often feel that their current training in this area fails to give them strategies for the effective use and management of computers in their classrooms, sometimes because the training is too brief, or is irrelevant, or is ineffectively or inconveniently delivered.

5.4.2 Pertinent Prior Research

These problems are not new. A considerable amount of discussion has been occurring since the early 1980s with respect to appropriate content and procedures for introducing teachers to the educational uses of computers. Debate continues to flourish around a number of different issues, particularly issues relating to the content of such training and to appropriate models for its delivery. Cost-effectiveness considerations -- given the large number of teachers requiring training, the different experience levels and needs of these teachers, and the continually changing nature of the field for which the training is meant to be pertinent -- have not yet identified a recommended model for the teacher training, either before or after the teacher is a practitioner.

However, some consensus has emerged with respect to these issues. For example, it is now considered appropriate that all teachers have some basic formal training with computers, although there is no agreement as to if this exposure should occur during preservice training, and if it does, at the expense of what other portion of the overall teacher training program. As to content, a general agreement is emerging that the majority of teachers do not want or need instruction in how to program or in how to generate their own software with authoring tools.

5.4.3. Training for Teachers as Personal Users of Technology

In addition, there is consensus about the value of teachers learning word processing and becoming familiar with representatives from each of the major areas of educational software such as simulations, drill and tutorials. The balance and sequence, however, of teacher familiarization with these different aspects of computer-related training has not been uniformly established. There is some evidence that initial computer experiences emphasizing the teacher's own use of the computer as a personal

tool may prove to be effective in increasing the likelihood that the teacher will eventually use a computer for instructional purposes with his or her students.

5.4.4 Alternative Delivery Strategies for Teacher Training

Delivery strategies for ongoing teacher training are also being critically examined, particularly with regard to organization. Using the new media as a vehicle for the delivery of such training experiences offers considerable potential, particularly from a cost-effectiveness perspective (as, for example, occurs when satellite transmission of specialized teacher training courses or seminars allows service to teachers in situations where it would be difficult and costly to provide training in their own environments).

5.4.5 Suggested Research Questions

With these considerations in mind, the following focuses are suggested as appropriate research topics:

5.4.5.1 What is the relative effectiveness of different models for teacher training in terms of the current needs of teachers in The Netherlands?

How well do different models cope with the necessity of training large numbers of teachers with different levels of skill? How effective are the various models with respect to the continually changing nature of the computer-field? How can the impact of different training methods be measured?

5.4.5.2 What should the content of teacher training be?

How much general knowledge about informatics and programming should be expected of primary teachers? of general secondary teachers? of vocational education teachers? How much of teacher training should relate to the development of teachers' personal uses of computers for record keeping and word processing? To what extent should teachers be trained to modify software? What is an appropriate balance between curriculum applications and informatics in the training provided for teachers in the different school sectors?

5.4.5.3 How can teacher training be most effectively organized?

Is training more effective on-site or at regional centres? Are there alternative methods of training, such as through self-help materials or television broadcasts, that can help meet the training needs of the large number of teachers in The Netherlands needing computer-related training? How will the teacher trainers, especially those at teacher training institutions, be trained?

5.5 Organizational Support for Teachers

In addition to training opportunities, a teacher's eventual usage of computers for instructional purposes relates to the type of support received for such use in his or her work environment. This support may be manifested in a variety of ways -- through the resources of hardware, sofware, time, and space made available to the teacher in order to prepare

for computer use with students; or through the personnel available to the teacher for technical as well as strategic support. We have discussed these perspectives before in the context of supporting the teacher in software evaluation activities. There are, however, a number of issues that deserve critical examination with respect to the level of support more generally available to the teacher with regard to compter use.

5.5.1 Perceived Inadequacies in Support Resources

It is common, both in and out of The Netherlands, for teachers to indicate they would like to do more with computers but that they do not have access to adequate resources in order to do so. These resources usually include time, hardware, and software. When to find the time to adequately prepare lessons incorporating computers or more generally to become more confident and competent with one's own level of computer-using facility is a serious problem for many teachers and the reason they frequently cite as underlying limitations in their eventual use of IT with their students.

Perhaps because it seems to relate more to procedure than to a conceptual educational issue, the impact of more or less preparation time for teacher deployment of computers for instructional purposes has received little focus as a research issue; it is accepted as a truism that more time for preparation would result in better preparation and in more effective classroom practice. Such an assumption should be looked at more systematically, within the context of the investigation of a variety of organizational arrangements all aimed at giving teachers more time and opportunity to prepare themselves outside of the classroom for computer use within the classroom. One frequently mentioned strategy is to make a computer identical in model to the machine the teacher has access to at school available to the teacher at home for preparation purposes. This approach still has limitations -- no technical support is available to help the teacher if procedural problems arise and the presumption is made that teachers will do their computer-related professional development on their own time and in competition with other preparation activities in which they are already involved.

5.5.2 Issues Relating to School Technology Support Persons

Teachers commonly acknowledge that the support they receive from a school computer system person is another factor in their eventual usage of available technology for instructional purposes. There are a number of issues relating to this type of support that need to be investigated. One relates to training and upgrading -- who trains the support persons? Where do they receive such training? What should the content of such training be? How much of the content should focus on technical updating and how much on pedagogical considerations? How can ongoing professional support for the support persons be most efficiently provided? How can a single support person, without being personally overloaded, respond to the practical and strategical needs of a staff where a large proportion of teachers wish to make fuller use of technology?

These issues may seem to be exclusively the domain of policy makers because of the financial considerations involved in any action regarding the issues. However, it is appropriate in a research framework to consider the implications to the system of not providing adequate support for computer systems persons and to advise on the likely consequences of different policy strategies regarding these persons as well as associated issues related to 'released time' assignment for computer-related support activities.

5.5.3 Information Transfer

Moving outside the school setting, the support framework available to the teacher through the larger educational support system is also an important variable in the teacher's eventual use of computers for instructional purposes. Aspects of this larger support system have already been commented upon; these include organization for teacher software evaluation and for teacher training more generally. They also relate to the need for better information transfer between teachers and schools and between teachers and specialists working on innovative applications of technology in the classroom. Teachers frequently comment that they feel they lack access to appropriate information; however, the problem of adequate information dissemination is not limited to teachers, but characterizes the situation perceived by individuals throughout the professional community involved with the computer in education. How to become better aware of and be more systematically informed about pertinent developments in a rapidly changing field is a major problem at all levels. How to translate these continual changes into appropriate and manageable information for practitioners is a major challenge.

5.5.4 Suggested Researach Questions

Given these considerations, various organizational issues are recommended as appropriate focuses of applied research:

5.5.4.1 What sorts of organizational and professional support are most valuable for teachers in terms of their ongoing needs for preparation time and professional development in the computer area?

Can a formula for teacher preparation time be found that balances teacher needs with cost realities in the school? How can on-site computer systems persons be most effectively supported in their work? How can they be adequately trained? What are the likely consequences of not having school support persons if resources for them are not available?

5.5.4.2 How can information transfer between teachers, schools, and support agencies concerning computer-related developments and issues be improved?

What methods of information transfer are most cost-effective? How can these types of effectiveness be evaluated? Are there special needs relative to computers in the various school sectors that are not as well met by the existing educational support system as they might be through specialized regional or national institutions developed directly to focus on teacher support for computer use? How can issues such as these relating to infrastructure be most effectively investigated?

5.6 Physical and Social Organizational Considerations

5.6.1 Physical Organization of Hardware

Research indicates a relationship between level and type of computer usage in a school and the physical organization of school hardware (such as in computer laboratories or distributed witin classrooms). Laboratories are accepted as necessary and desirable organizational modes for school computer resources, yet research shows that the concentration of school

resources in a laboratory environment can result in little or no usage of the facilities by the majority of teachers in the school. Also, the centralized laboratory environment may not be an appropriate locale for the integration of computer use as a tool within the context of lessons outside the informatics area. The language teacher, for example, who would like his students to make intermittent contributions to a data base of vocabulary which can later be used by the students for personalized language drill is not serviced by access to a full laboratory away from the classroom environment but is better served by having stand-alone hardware immediately available in the classroom itself.

5.6.2 Social Organization of Computer Use

There is another area of organizational strategy that has shown itself to be an important variable in the instructional impact of computer use in schools. This area relates to the social organization of student use with respect to computers.

The assumption that an optimal goal is that each student can work independently at his or her own terminal has been challenged depending on the type of computer-related experience involved. Some types of computer interaction are enhanced by group use of a single computer and there is some research support for the value of working in pairs rather than alone at a computer even for drill-type activities. The impact of student characteristics as well as instructional objectives on decisions about optimal student:machine ratios requires careful research; no simple standard of student:machine ratio can be unilaterally endorsed. Also the impact of hardware characteristics themselves on student learning need more careful study, especially with respect to innovations such as local area networking and access to telecommunications.

5.6.3 Suggested Research Questions

Within these perspectives, the following research focuses are recommended:

5.6.3.1 What are the practical and pedagogical considerations associated with different physical groupings of school computer resources?

In what ways does the laboratory configuration of school computers impact on student usage and on teacher decisions about instructional uses of computers? Does local-area networking affect teachers' instructional decisions?

5.6.3.2 What are the implications of different groupings of students with respect to computer use?

What sorts of learning experience are best presented through individual use of a computer? When might pairs of groups of students relative to a single computer be more effective pedagogically? Can we recommend different student: computer ratios for different types of learning situations? How can the teacher integrate the use of a single classroom computer within the demands of overall classroom management?

5.7 Issues Relating to Software Development and Characteristics

Research supports the common knowledge that there are many issues related to software development or adapatation which require continued examination. Some issues are particularly important to vocational education teachers who must deal with the choice of using professional-quality industrial software or instead of acquiring some kind of simulation or educational shell relating to the professional software.

In addition, there are important areas of theoretical work with applications to software development that are potentially too profitable to be overlooked, even in a research orientation which emphasizes implementation. These include work with new software environments such as hypertext and fundamental research into the development of expert systems and more efficient user interfaces.

5.7.1 Suggested Research Questions

Major research questions include the following:

5.7.1.1 In vocational education, what sort of software is most appropriate?

Are students better served by having access to software and hardware that duplicates what they will use in the workplace, or by using simulations of such materials?
Can user interfaces be built around professional packages to provide tutorial support for students?

5.7.1.2 What characteristics of the user interface are most critical for subsequent student learning?

To what extent should standardization of user interface characteristics occur for the differnt educational sectors?

5.7.1.3 How can new developments in hypertext, artificial intelligence and expert system research be incorporated into usable classroom learning tools?

5.7.1.4. To what extent do teachers wish to adapt software for their own situations?

What sort of software support should be available to facilitate this kind of teacher control?

5.8 Toward the Improved Assessment of the Impact of Computers

5.8.1 Specific Methodological Problems Associated with the Assessment of Student Gains From Computer Use

The final purpose of all of the initiatives relative to teacher training, organizational support, and software development and distribution is to promote more effective student learning than occurs using traditional technologies. Yet, there is a continued frustration with the difficulty of measuring such gains if or when do they do occur. This is particularly so with respect to increases in higher level cognitive activity, such as problem solving, critical thinking, and metacognitive processing. These difficulties assume critical importance when higher level outcomes are given as major reasons for extensive expenditures of time and money on computer applications in schools. However, existing measurement techniques

for student performance relative to computer-based learning experiences are often cited as being unreliable.

5.8.2 Methodological Considerations Associated with Overall Evaluation of Technology-Related Practice and Policy in Education

In addition, valid and manageable methodology for the more general evaluation of computer-related practice and policy in the school setting is as yet little understood or practiced. There are particular problems involved with the evaluation of technology-related activity which transcend those associated with evaluation of school practice in general. One problem relates to the rapidly-changing and exploratory nature of technology activity; evaluation should not be postponed until a stable situation presents itself for more traditional evaluative considerations, as too many important decisions must be made in the intervening short term period. A second problem relates to the indistinct nature of objectives with regard to technology use in schools -- often such use is belief-driven rather than outcomes-driven and therefore constructive evaluation apparently lacks a focal point. Special consideration should be given to manageable methodologies that can give valuable evaluative feedback to teachers and decision makers during the current phase of school computer activity.

5.8.3 Suggested Research Questions

Because of these assessment limitations, we are frustrated in producing effective evidence to support the relative impact of one type or arrangement of computer-related learning experience relative to another. Before sensitive large-scale examination of the impact of various types of computer use on student learning can occur we must do more preliminary work on the methodology of measuring and interpreting these sorts of impact. The following research areas are recommended:

5.8.3.1 What is an appropriate methodology for school or regionwide evaluation of computer-related policy and practice?

5.8.3.2 How can the cost-effectiveness of different computer (and non-computer) applications be calculated?

How can cost-effectiveness considerations be used as a basis for subsequent planning and budgetting in a school or region? What are appropriate criteria for cost-effectiveness appraisals?

5.8.3.3 How can we reliably identify gains in higher order thinking and how can we argue that such gains transfer from computer experiences in school to a broader application?

5.9 Summary

Within this framework, we have categorized a set of suggested research issues based on current needs in The Netherlands relative to the effective application of IT in education. The ultimate goal of the recommendations is to improve student learning; however, we believe that considerable preparatory work needs to be done before we can expect to see such improvements. We belive that disciplined inquiry relative to the issues identified in this framework can help the advance of this prepatory work.

6. The Research Proposal

6.1 Final Proposal

6.1.1 Influences on the Final Proposal

The final research proposal was based not only upon the framework described in section 5, but also on a number of other considerations:

- The budget constraints.
- The new plans developed in the PRINT-project, the successor of the INSP, indicating that activities continued to be organised by school sector, and therefore each school sector (primary, general secondary, vocational) should have its share in the research proposal.
- Continuation of the 'Experimental Schools' Project.
- Stimulation of cooperation in the basic research area, certainly in relation to the application of artificial intelligence techniques in education.
- Usefulness of the results to the current educational system.

6.1.2 Budget for the Research Activity

The available budget (approximately equal to the research budget during the INSP) was split up in two categories: 40% for the Experimental Schools Project and 60% for other research projects. As the schools participating in the Experimental School Projects also received other finances for their computer-related activities, the emphasis on this kind of action research is remarkable. It shows the conviction in the Netherlands that getting insight into the integration of computers into the curriculum will only appear through a global approach in which research is directly combined with hands-on experience in real classroom settings.

6.1.3 Selected Priorities

Within the budget for regular projects and based on the influences described in section 6.1.1, the following priorities for the next phase of SVO computer-related educational research were selected:

- Courseware evaluation by teachers: procedures and criteria.
- Research toward the effects of alternative approaches to the inservice training of teachers; research into the possibilities for teachers to use computers at home for preparation of their lessons and to make fuller use of student feedback; research toward the possibilities of using telecommunications in the context of inservice training.
- Research about the kinds of computer-aided learning felt to be useful in vocational education. How can professional packages be used and integrated in regular curricula, for instance, using embedded training techniques? What kind of computer applications should get priority in vocational education?
- Research about cooperative learning and computers.
- Methodological studies on effect evaluation relative to the influence of computers on higher cognitive skills and on education more generally.
- Research toward the applicability of artificial intelligence techniques to the production of courseware.
- Development of interactive coaches.

6.2 Evolution of the Proposal into a New Research Plan

After the research proposal was published (Autumn, 1988), a two-day working conference was organised in order to discuss its specifics. At this conference representatives of the Dutch educational research institutes were present, as well as representatives of the Dutch school inspectorate and the schools.

The conference concentrated its discussion upon two major topics:

- The value of the Experimental Schools Project.
- The value of the implementation orientation of the research proposals in contrast to an orientation toward more theoretical research issues.

For the Experimental Schools Project the issues were raised that within the available project proposals specific research questions were not (yet) clearly formulated, that there was no experimental design available, and that there were too many opportunities to spend much time on development work (developing courseware, developing inservice training) and not enough on research. Although many of these remarks made sense, everybody was convinced that a new 'global' and unorthodox approach was necessary. Generally speaking, there were some doubts about spending a considerable amount of money without a higher probability that practical results will appear at the end of the project. The Experimental Schools Project was finally supported, but it will have to soon present a more concrete research plan and "concrete results."

The other main discussion point was about the necessity of doing applied research in this area versus the need for more theoretical research. Some claimed for more emphasis on theoretical research as no one can predict what new horizons will be opened by theoretical research results, horizons that maybe will change our view about computers and education in a radical way. No one wanted to argue against this position. However, considering the budget constraints and the need for immediate results, these interventions did not lead to significant changes in the research proposal.

After plenary sessions, working sessions, and much informal discussion, the content and approach of the research proposal as described in sections 5 and 6.1 was approved.

7. Conclusions

In this paper we have tried to develop the following three points:

- Research plans should be formulated within a concrete and well defined framework.
- The present orientation of research plans in this area should focus much more upon implementation issues then on theoretical research questions.
- There is a need for international cooperation in this area.

We have used the past and present experiences in the Netherlands to support these conclusions. The first phase of the Dutch experience supports the first of these points. The second phase is contributing to our recognition of the importance of the second point. Both phases of the Dutch experience reinforce the complexity of the overall task and support our third conclusion.